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BOTANY.

The Development of the Ovule of Aster and Solidago.—The following is from an unpublished paper on The Development of Flower and Embryo-sac in Aster and Solidago, by Dr. George W. Martin. The work was done in the botanical department of the Indiana University in the year 1891–2:

A short time before the floral organs attain their maximum length there appears at the bottom of the ovarian cavity a rounded excrescence; this is the incipient ovule, the promise of a future seed. This incipient ovule does not arise from the bottom of the ovarian cavity, but a little above the lowest point. Therefore, the ovule is not the terminal structure on the floral axis, for, by careful focusing, the apex of the fascicular system is seen to end very abruptly at the bottom of the ovary cell. To the right and left of the axial bundle of the pedicel, a little below the apex, are given off fibro-vascular bundles which traverse both sides of the capellary leaf. It is in the region of one of these lateral bundles, beneath the epidermis, where arise the primitive cells that arch upward and give rise to the funiculus and the nuclear ovule. Subsequently a branch of this lateral bundle enters the funiculus.

At first the ovule consists of a mass of cells, the tissue of which is soft and cellular, and is designated the nucleus of the ovule or the nucellus. By further development a large nucleated cell appears within this nucellar tissue, which soon divides, the apical cell of which becomes the mother-cell of the embryo-sac. In its early development the nucellar body is almost orthotropous, but by further growth it becomes curved (caused by a stronger growth on one side) at the point (base of the nucellus), where the integument originates. At first the integument appears as an annular ring; as growth takes place it forms a complete wall around the nucellus; as the wall encroaches upon the apical portion of the nucellus the latter becomes more and more curved, but does not seem to be wholly inverted until the integument completely surmounts it, even passing far beyond the nucellar apex. Thus, we have an ovule which is anatropous, having a single integument, though very thick and forming the greater mass of the ovule before fertilization is accomplished, investing a small central portion, the nucellus; and the latter, which consists of but one layer of cells, in turn surrounds a more central portion, the embryo-sac. Originally this sac consists of but a single nucleated cell, which, when division is complete, forms a central row of cells. The nucellus in process of growth becomes very much elongated; its cells are well defined and nucleated; likewise the mother-cell of the embryo-sac, though primitively polyhedral in outline, but later more oval in contour, elongates and contains a nucleus with nucleolus, imbedded in a rich mass of protoplasm. In some sections the nucleus appeared to be elongated in the same direction as the embryo-sac.

During the subsequent growth of the integument and the nucellus, the embryonal sac enlarges, and the nucleus of the mother-cell undergoes sub-division. In a specimen seen the nucleus had divided, and the mother-cell afterward separated into two equal parts by a transverse wall, each part containing a nucleated cell. Presently the two nuclei divide, a transverse wall is formed in each half, and thus we have, at the end of the second and last sub-division of the mother-cell of the embryo-sac, four equal, nucleated cells. At this stage of the embryo-sac there is a very close analogy to the division of the mother-cell into four cells worked out by Strasburger in Polygonum and Senecio. The cross walls formed between the cells are very strongly refractive and much swollen; the middle transverse wall is remarkably distended, and persists much longer than the other two partitions; in several sections the middle wall was found intact when the contents of the cells were completely absorbed. Of the four cells into which the primitive mother cell of the embryonal sac is now divided only the lower one is characterized by further growth; this cell, therefore, becomes the true mother-cell of the embryo-sac. Subsequently the protoplasm of the upper three cells becomes viscid, the nuclei show disintegration, and the upper wall of the lower, club-shaped cell (mother-cell) indicates a rigid turgescence. When the upper three cells begin to disorganize (in centrifugal order), they become crescent-shaped, their nuclei disappear, their walls are displaced, and the cell contents are absorbed by the encroachment of the lower mother-cell. After the cells are completely disorganized and absorbed the mother-cell assumes a central position in the embryo-sac.

Simultaneously with the obliteration of the upper cells of the embryo-sac the one-cell-layer of the nucellus undergoes a similar process of disintegration. The first mark of displacement is shown by the reduction of the cell contents to a granular mass of protoplasm; then follows the disappearance of the transverse cell walls. The order of nucellar displacement begins at the apical end of the nucellus and proceeds towards its basal portion; finally the whole nucellar tissue is displaced and absorbed by the embryo-sac, which subsequently becomes very much enlarged. Sections were made showing a partial obliteration of the nucellus, and at this period of growth the embryo-sac is completely filled with protoplasm, in the central portion of which is located the mother-cell, with a vacuole both above and below it. Later sections showed a complete displacement of the nucellus, an elongation of the embryo-sac, a further separation of the vacuoles, the first division of the mother-cell into two daughter cells, each moving, the one to the upper the other into the lower end of the embryo-sac. In the next stage of development we have the first division of the polar nuclei, thus making two nuclei in each end of the embryo-sac. The two upper nuclei rest within an accumulation of protoplasmic substance, while the two lower nuclei rest within a less dense plasma between an upper and a lower vacuole which show a longitudinal expansion. Previous to the last division of the polar nuclei a longitudinal increase of the whole embryo-sac takes place. Subsequently each of the two nuclei divides, and we have four nuclei occupying opposite extremities of the embryo-sac. Thus, division is complete, and the upper cells give rise to the egg-apparatus, while the lower are designated antipodal cells. The next stage of development is characterized by the ascent of one of the antipodal cells toward the center of the embryo-sac. This nucleus is imbedded in a dense mass of protoplasmic material separating two large vacuoles. Of the three antipodal cells remaining, the two upper of which lie alongside and impinge on each other, also rest in a plasma bridge separating two vacuoles, the upper of which is the larger, and the lower one of the two previously mentioned vacuoles. The lowermost cell is partly obscured by the impingement of the lowermost vacuole.

At the micropylar end of the embryo-sac the cells have a far different significance. One of the cells in its descent toward the center of the sac meets its fellow from below and both coalesce, thus forming the secondary or endosperm nucleus. The three remaining cells, though naked like the three opposite, but surrounded by a dense mass of protoplasm, constitute the true egg-apparatus. The two upper cells of the egg-apparatus, which lie side by side, occupying the whole tapering anterior end of the embryo-sac, are the synergidæ; at their lower extremity, occupying nearly the whole width of the sac, lies a large rounded cell, the oosphere.

In further development the embryo-sac becomes very much swollen, which is a characteristic feature both before and after the process of fertilization. But fertilization in this case has not yet been accom-

·plished, as the perfectness of outline of the synergidæ amply testify. The upper vacuole shows a contraction toward the upper extremity of the embryonal sac, and is more oval in outline. At this stage, also, the upper polar nucleus exhibits retarded action in its descent toward its counterpart from below, even in many cases refusing descent until after or about the fertilization period.

Botanical Teachers and Text-Books.—At its best, the botanical text-book is a necessary evil. One student and one teacher is the ideal college. The time-worn epigram of Garfield about Mark Hopkins and the log contains the gist of the matter. But where the class-system is necessary our few great teachers are brought into contact with the multitude of learners by means of the text-books. A man's personality is, however, rarely caught in print. The peculiar charm of his presence and the inspiration of his own living enthusiasm is lost, while, in its stead, there may be but a dry collection of ex-cathedra facts and generalizations. Therefore, one must supplement the cold repast with something appetizing and warm of one's own, if one has anything of one's own to offer. And in this connection it may be well to emphasize the necessity of interest and intelligence on the part of the teacher. Of course, an uninterested teacher is forever an uninteresting teacher. A teacher who is content with "hearing the lesson" is an enemy of education. The idea which some have that the text-book is the teacher and that the individual by courtesy named "teacher," or sometimes "professor," is merely a kind of intellectual galvanometer which indicates by a series of figures running from one to ten whether the electric current of information from text-book to pupil is relatively strong or weak; this idea, be it respectfully said, is so ingeniously perverted that it quite commands our admiration. Deliver us from botanical teachers who hear the lessons.—CONWAY MACMILLAN, in *Education.*